Rocky Flats Environmental Technology Site: Actinide Migration Evaluation
Meetings June 5-6, 2000
Advisory Group
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Summary and recommendations for path forward

We see great value in the integration of projects and are pleased with the present evolution of efforts in erosion, transport and chemical speciation modeling, coupled with sampling of storm water, road soils, and alluvial ground waters Simultaneously, we see a need to increase AME activities focused on the industrial area, as this is essential for meeting the closure targets Contributing to this integration of projects and increase in focus on the industrial area, we are looking forward to the reports on the strategies for D&D, characterization and environmental remediation Linkage and planning for site closure and long term stewardship activities is also of interest for future discussions

Progress and integration

The information generated by the erosion and transport modeling activities has progressed sufficiently for integration into operational planning, as well as providing a tool for design and evaluation of site configuration and remedial actions From the suite of detailed process results developed to date, we see immediate opportunities to extract high level data essential to planning for capture of storm mobilized actinides by ponds and wetlands

The recent integration between D&D and AME activities is very valuable and provides an excellent example of work that utilizes detailed scientific measurements to resolve a near-term applied problem

In view of their direct connection at RFETS, the Group recognizes the benefits of continued coordination of Site activities in monitoring and modeling groundwater and surface water flow, and transport processes Further coordination and use of common or integrated data sets between water and wind erosion modeling activities will be valuable Coordination of presentation tools (i e GIS mapping) and formats would also be beneficial

Results and Discussions

Erosion "primer" – Leonard Lane

Rangelands and pastures are found in every state and cover 55 percent of the land surface of the United States Taken as a whole, from western deserts and grasslands to meadows and woodlands, rangelands comprise over 360 million hectares or some 80% of the land in the western states Add to this the pasture lands, scrub-lands and other non-cropland and non-forest lands in the eastern states and we have a land classification we call rangelands This very broad land classification is called rangeland herein for simplicity and to avoid terms such as non-cropland, non-urban land, and non-forests This very broad definition of rangelands makes up most of the federal, including military, lands in the United States, including RFETS

Soil erosion on rangelands has been widely recognized as a problem for most of this century Rangeland soils are typically fragile, thin, and relatively nutrient poor in comparison with cropland soils These soils and the vegetation communities they support have evolved together and should be considered as a soil-vegetation-land use/management complex Cropland-based erosion science and its research and modeling approaches treated the soil somewhat apart from the vegetation and land management Moreover, tillage practices tend to homogenize the surface soils and redefine the initial conditions each cropping season We need to understand rangeland soil erosion processes in the context of their natural setting and as influenced by our land use and management practices Exclusive of human disturbance, precipitation and water flow are major influences on soil structure and transport processes

At the small scale, raindrops impacting on the soil surface induce tremendous hydraulic forces which tend to crater the soil surface, and in the presence of a thin sheet of water on the surface, rebound in what is called a jet This jet thrusts water and soil particles upward producing a splash and intense localized erosion Under sufficiently intense and sustained rainfall, overland flow (also called sheet flow at this scale) begins and the detached soil particles (and aggregate particles of soil) are transported downslope The soil particles and soil aggregates being transported are called sediment particles This is called interrill erosion or sheet erosion Any cover material shielding the soil surface from raindrop impact tends to reduce the cratering, rebound jet, and thus the detachment and splash of soil particles In general, cover on or near the ground surface is much more effective in reducing raindrop splash erosion than is vegetative cover above the soil surface Surface cover also forms hydraulic roughness that reduces the velocity of sheet flow and its ability to transport detached soil particles

Water doesn't travel far before it begins to concentrate in soil depressions and flow paths The depth of flow, velocity of the flow, shear stress on the soil surface, and the flow's ability to transport sediment are, in general, greatly enhanced by flow concentration Sediment delivered to the concentrated flow

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paths by splash or sheet flow transport is then much more rapidly transported in the concentrated flow In addition, the flowing water exerts shearing forces on the soil surface upon which it is flowing These forces may literally tear or rip aggregates and soil particles from the soil and bring them up into the flow where they may be transported downslope As the slope steepness increases or decreases in the direction of flow some areas are subject to net detachment of soil particles and in other areas soil particles settle out of the flow and are deposited Detachment and deposition are occurring in all areas, but we speak of areas of net detachment or net deposition Sometimes we drop the word net and just speak of areas of detachment and areas of deposition In the case that both net detachment and net deposition are zero, there is an equilibrium condition where the capacity of the flow to transport sediment is exactly matched by the amount of sediment contained in the flowing water In the current context, these processes of soil detachment, sediment transport, and sediment deposition in concentrated flow are called rill erosion Vegetative cover above the soil surface has some limited impact on rill erosion In contrast, cover in contact with the surface that isn't swept away by the flow significantly reduces flow velocity and shear stresses acting directly on the soil and increases hydraulic roughness Thus, the detachment and transport of soil particles decreases and the rate of sediment deposition may increase A central challenge of erosion and sedimentation research has been to measure, understand and model these complex processes we call interrill and rill erosion in overland flow

Before discussing erosion processes at the hillslope scale, it is necessary to introduce the sediment source-transport-sink concept An idealized fluvial system conceptualized by Prof Schumm of Colorado State University, consists of three zones characterized as areas of sediment source, transport, and sink Zone 1 (the source of runoff and sediment) is described as the drainage basin, Zone 2 (the transfer component) as the main river channels, and Zone 3 (sinks or zones of deposition) as the alluvial channels, fans, and deltas, etc

This conceptual model is useful in generalizing processes at the mid- to large watershed scale (i e on the order of 10^3 sq km or larger) However, a high degree of similarity of watershed planimetric features has been found over a wide range of scales If true, Schumm's conceptual model of sediment source, transport, and sink zones would be repeated across a range of scales Physical features that correspond to Schumm's three zones can be seen on row sideslopes in cultivated fields or within 1 sq m rainfall simulator plots on rangelands Satellite imagery shows that these physical features are also exhibited in large-scale systems such as the Nile and Mississippi rivers The wide-scale of application of the sediment source-transport-sink concept for describing processes controlling sediment yield suggests that sediment yield should be strongly influenced, though not completely determined, by the contributing drainage area

A hillslope can be defined as the zone of the landscape from the crest of a ridge along the slope in the direction of flow to a defined drainage, water body, or other feature interrupting the overland flow profile at the toe of the slope A hillslope's length, slope steepness, orientation, and profile shape (convex, concave, uniform, or complex profiles made up of combinations of the other shapes) serve to describe it Appropriate hillslope lengths range from less than a meter to over a hundred meters, and corresponding area scales range from less than a square meter to as much as a hectare or more

At the hillslope scale, where channelization occurs at the microtopographic level and larger channels are usually absent, overland flow processes dominate Land use and disturbances affecting these processes are also important and significantly influence sediment yield from hillslopes As stated earlier, the sediment source-transport-sink concept applies at this scale and is observable in the field

Processes involving vegetative canopy cover, surface ground cover, and topography play a major role (along with rainfall amount and intensity) in controlling infiltration and runoff as well as sediment detachment, transport, and deposition in overland flow on rangelands The impact energy of raindrops at the soil surface is reduced due to their interception by vegetative canopy cover Most rangeland vegetation is of sufficiently small size that raindrop re-formation and fall results in much less energy than unobstructed rainfall on most rangelands The inherent soil erodibility controls the rate of soil detachment at the soil surface, but ground cover (rock, gravel, litter, and plant basal area) shields the soil surface from direct raindrop impact and significantly enhances infiltration Surface ground cover also significantly influences the hydraulics of overland flow, reduces flow detachment capacity, and reduces sediment transport capacity of the flow Finally, small sediment particles and litter combine with basal vegetation and microtopography to produce debris dams which result in water ponding and sediment deposition

Thus, soil erodibility, rainfall amount and intensity, vegetative canopy cover, surface ground cover, and topography (and their collective spatial variability) largely determine sediment yield at the hillslope scale They act to control soil detachment and runoff and in so doing impact the supply of sediment available for transport and yield and the amount of runoff available to transport it

Knowledge of the factors controlling soil erosion processes of soil detachment, sediment transport, and deposition allow us to construct mathematical simulation models (often just called simulation models) to simulate these processes over a rage of scales from experimental plots to small watersheds However, there are two main areas of uncertainty in use of these models to predict soil erosion processes

The first area of uncertainty is called systematic error and refers to how well the mathematical models represent processes in nature More complex, physically-based models are designed to reduce systematic errors However

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increasing complexity in simulation models results in an increase in another type of uncertainty, often called parameter or calibration uncertainty, results in errors in model predictions Therefore, professional judgment is needed to determine appropriate model complexity to balance these two types of uncertainty

Finally, properly selected and calibrated simulation models for erosion and sediment transport forms the basis for providing valuable erosion prediction and evaluation technology for use in analysis and prediction of contaminant transport at RFETS

Erosion and Transport Modeling – Win Chromec & Greg Wetherbee

An update on progress in modeling sediment transport and associated plutonium transport at RFETS was presented Development of the description of hillslopes, soil characteristics, and surface water channels has allowed development of an integrated model system for erosion and actinide transport using the WEPP and HEC-6T computer codes The results of calibration runs and system evaluation have provided the first opportunity to examine specific climate and cleanup scenarios for RFETS While the uncertainties and integration with site specific data requires continued development and effort, these initial model simulations provide an valuable perspective on the efficacy of cleanup to various proposed levels (e g Tier 1 vs Tier 2 vs RSALs levels in the buffer zone) and the impacts on surface water quality Of direct importance for near term cleanup decisions and strategies at RFETS is the ability to compare and improve surface water monitoring and evaluation field programs based on the simulation results, thereby utilizing the erosion and channel flow models as a design and evaluation tool set In particular, these simulation tools need to be used to examine nonlinear process relationships and integrated results --- avoid relying on linear fitting of secondary data from the model simulations

Several targeted simulations and evaluations have been identified by the advisory group as having specific value for site planning Pond and channel transport and capacity simulations need to be developed for both design storms and continuous climate simulations to allow evaluation of storage capacity and actinide transport in support of continued site operations and future passive systems design constraints (e g pond C-2 and the SID) Secondly, evaluation of specific discharge events associated with stormwater sampling by the Texas A&M (Santschi et al) researchers would be valuable to put the analytical results in context Third, in parallel to sampling and development of strategies for roads and disturbed areas in the buffer zone, specific evaluations need to be developed for these heterogeneous systems

Plutonium and Americium Drilling-Artifact Contamination Investigation – Robert Smith

The initial results from four new wells drilled to evaluate Pu and Am contamination below the soil layers were presented Old wells paired with the

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new wells have shown persistent contamination in water samples, with one hypothesis being that contamination was carried down from surface soils during drilling New wells were installed within the 1 pCi/gm contour of the contaminated area, but not in the 903 pad due to complexity and cost of drilling The new wells were designed to eliminate or limit contamination from surface soils by installing surface casing to a depth of ~2ft (64cm) The surface cased zone was then cleaned by hand, before completion of drilling to depths of between 14 6 and 22 5 feet All four wells have been sampled for water contamination, with one well resulting in no detection of Pu and Am Low levels (<0 06 pCi/Lor less) of Pu or Am contamination were detected in the other three wells Detection of contamination in all of the well samples is being evaluated through continued sampling of both new and old wells

Several options exist for further testing of the source of contamination in the old and new wells Samples should be subject to parallel analyses using long term counting of large volume samples Size fractionation and concentration using techniques being applied to surface waters could also provide insight into the characteristics of the contaminant materials and their similarity or relationships to surface contamination In addition, isotopic analyses of Pu would be useful in evaluating source term from RFETS contamination versus fallout

Uranium geochemical modeling update

Jim Ball gave a short presentation updating recent progress on the evaluation and interpretation of ground water chemistry of the uranium and nitrate contamination plume at the Solar Ponds area A discrepancy was noted earlier that charge imbalances in the ground water analyses increased significantly for the samples containing the highest concentrations of nitrate The type of charge imbalance and the imbalance between measured and calculated conductivity indicated that an anion was missing from the analyses The source of the missing anion component, thought to be a soluble organic compound, turned out to be misreporting of the nitrate concentrations It was thought to be nitrate reported in terms of the formula NO_3 whereas it was actually reported in terms of elemental N Once this discrepancy was discovered and corrected, there were only two or three poor charge balances which could not be explained and did not affect the interpretation The mineral saturation indices that had previously been calculated for possible uranium mineral solubility controls were not affected significantly The ground waters are still significantly undersaturated with respect to all U(IV) and U(VI) minerals for which saturation indices could be calculated Hence, mineral solubilities do not appear to impede the movement of uranium in the ground water Jim also reported that the water isotope data (^{18}O and ^{2}H) indicate that an evaporation signature could be discerned in the ground waters and that this result tied the uranium and nitrate contaminant plume to the Solar Evaporation Ponds (SEP) The results give a better picture of the nature of the contaminant plume and continue to underline the importance of determining

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the reason for uranium attenuation compared to the transport of the nitrate plume Discussion on this issue led to the possibility that in addition to uranium adsorption, evaporation and precipitation of uranium in the vadose zone, or uranium precipitation in the aquifer immediately below the SEP, there may have been precipitation and deposition of uranium in the sludge of the SEP (which has now been removed) Whether the uranium attenuation is really a result of sludge deposition or aquifer reaction and precipitation must be determined for proper remediation

Documents provided to advisory group

Robert Smith (RMRS) viewgraph set

Documents and information requested for advisory group

Leonard Lane viewgraphs

Win Chromec viewgraphs

Requested presentations at future meetings

Laura Brooks – stewardship – request for presentation on strategy and planning

Lane Butler – Industrial Area strategy for characterization and environmental remediation

Solar pond archive samples to define potential source term, information on other uranium contamination source sites and problems

Standard analyses labs and processes – need more information on monitoring assays – is Mass Spectrometry the only reasonable analytical technique for these groundwater samples

Jeff Stevens and Pat Ervin – D&D plans

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Participants in AMS technical meetings

Name	Organization
Greg Choppin	FSU
David Clark	LANL
David Janecky	LANL
Kirk Nordstrom	USGS
Mike Peters	RMC/QA
Rob Smith	RMRS
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Greg Wetherbee	WWE
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Rick Roberts	Kaiser-Hill
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Dave Shelton	Kaiser-Hill
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Chris Hawley	International Engineering
John Corsi	Kaiser-Hill
Jim Ball	USGS

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